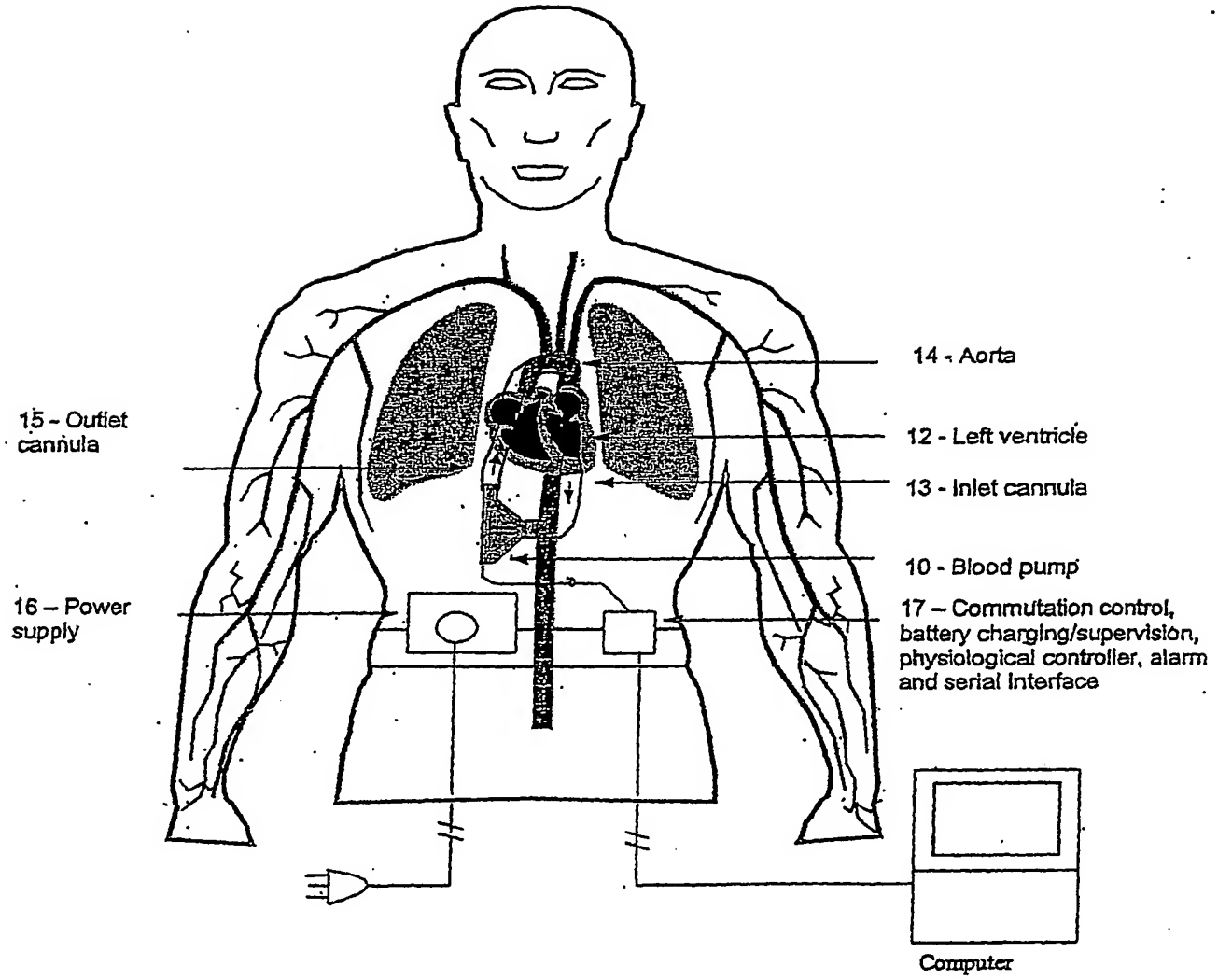

14 - Aorta
15 - Outlet cannula
12 - Left ventricle
13 - Inlet cannula
10 - Blood pump
16 – Power supply
17 – Commutation control, battery charging/supervision, physiological controller, alarm and serial interface
Computer

Fig. 1

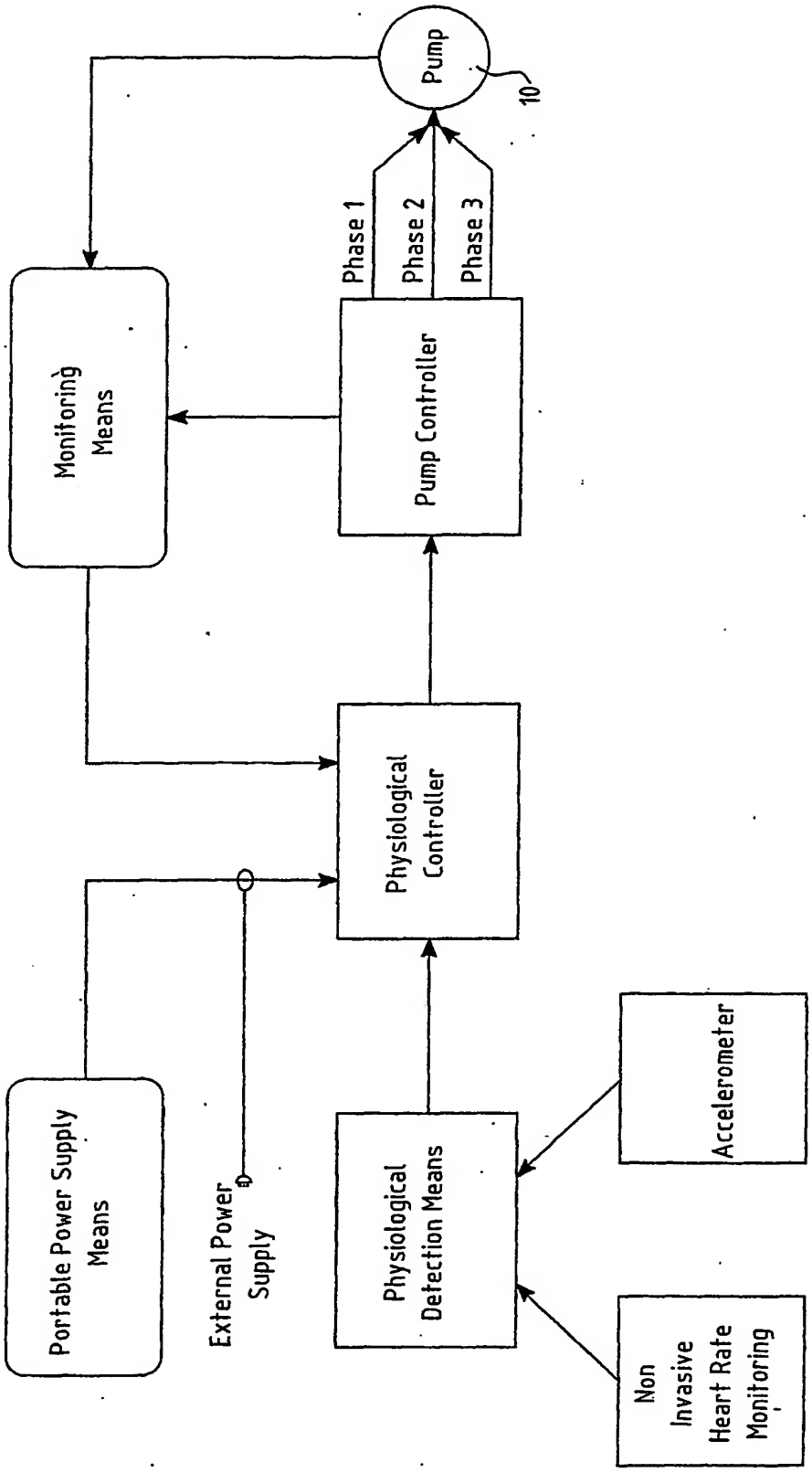

Pump
10
Phase 1
Phase 2
Phase 3
Monitoring Means
Pump Controller
Physiological Controller
Portable Power Supply Means
External Power Supply
Physiological Detection Means
Accelerometer
Non Invasive Heart Rate Monitoring

Fig. 2

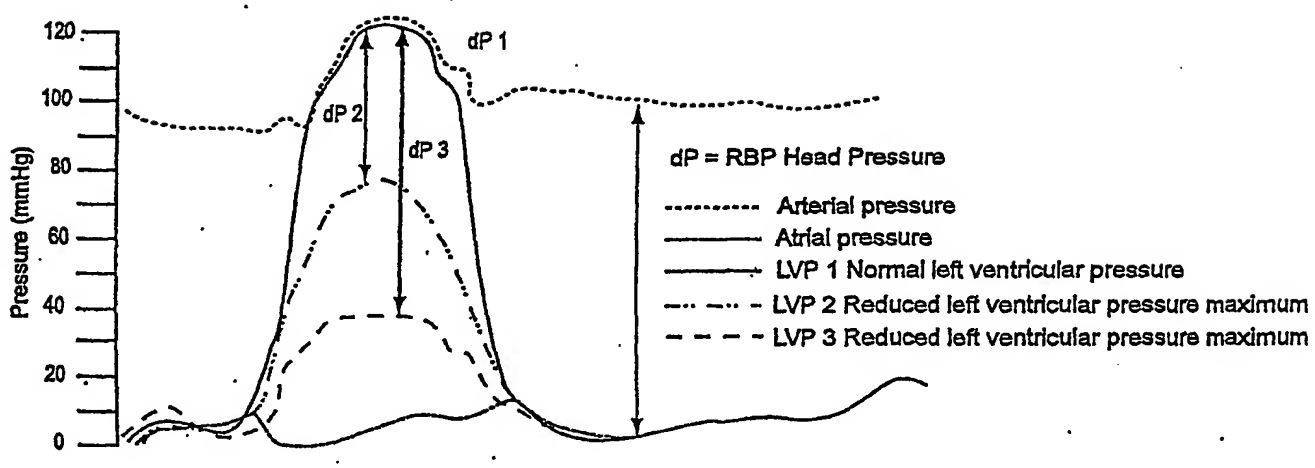

120
100
80
60
40
20
0
Pressure (mmHg)
dP 1
dP 2
dP 3
dP = RBP Head Pressure
Arterial pressure
Atrial pressure
LVP 1 Normal left ventricular pressure
LVP 2 Reduced left ventricular pressure maximum
LVP 3 Reduced left ventricular pressure maximum

Fig: 3

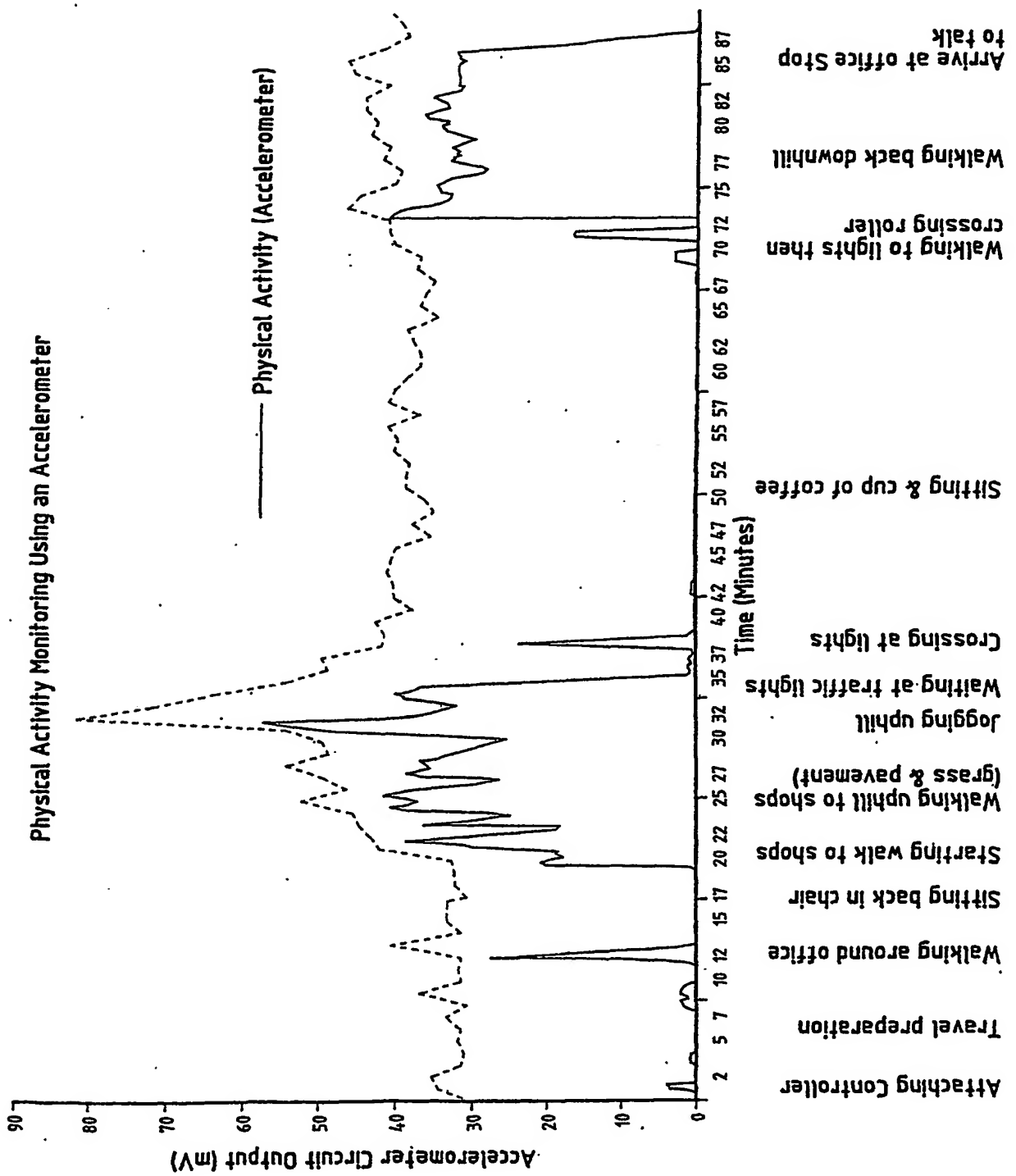

Physical Activity Monitoring Using an Accelerometer
Physical Activity (Accelerometer)
Accelerometer Circuit Output (mV)
0
10
20
30
40
50
60
70
80
90
Time (Minutes)
2 5 7 10 12 15 17 20 22 25 27 30 32 35 37 40 42 45 47 50 52 55 57 60 62 65 67 70 72 75 77 80 82 85 87
Attaching Controller
Travel preparation
Walking around office
Sitting back in chair
Starting walk to shops
Walking uphill to shops (grass & pavement)
Jogging uphill
Waiting at traffic lights
Crossing at lights
Sitting & cup of coffee
Walking to lights then crossing roller
Walking back downhill
Arrive at office Stop to talk

Fig. 4

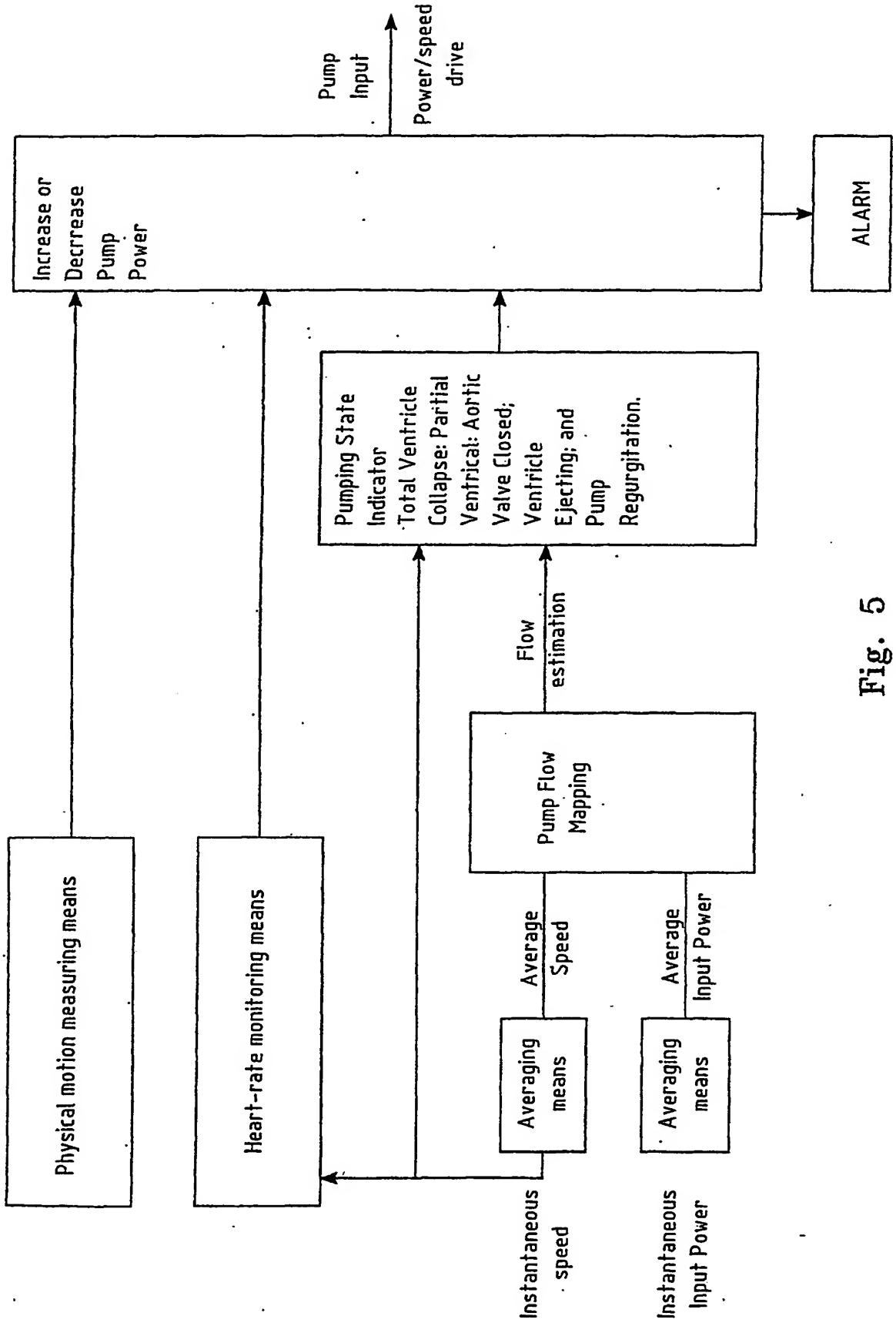
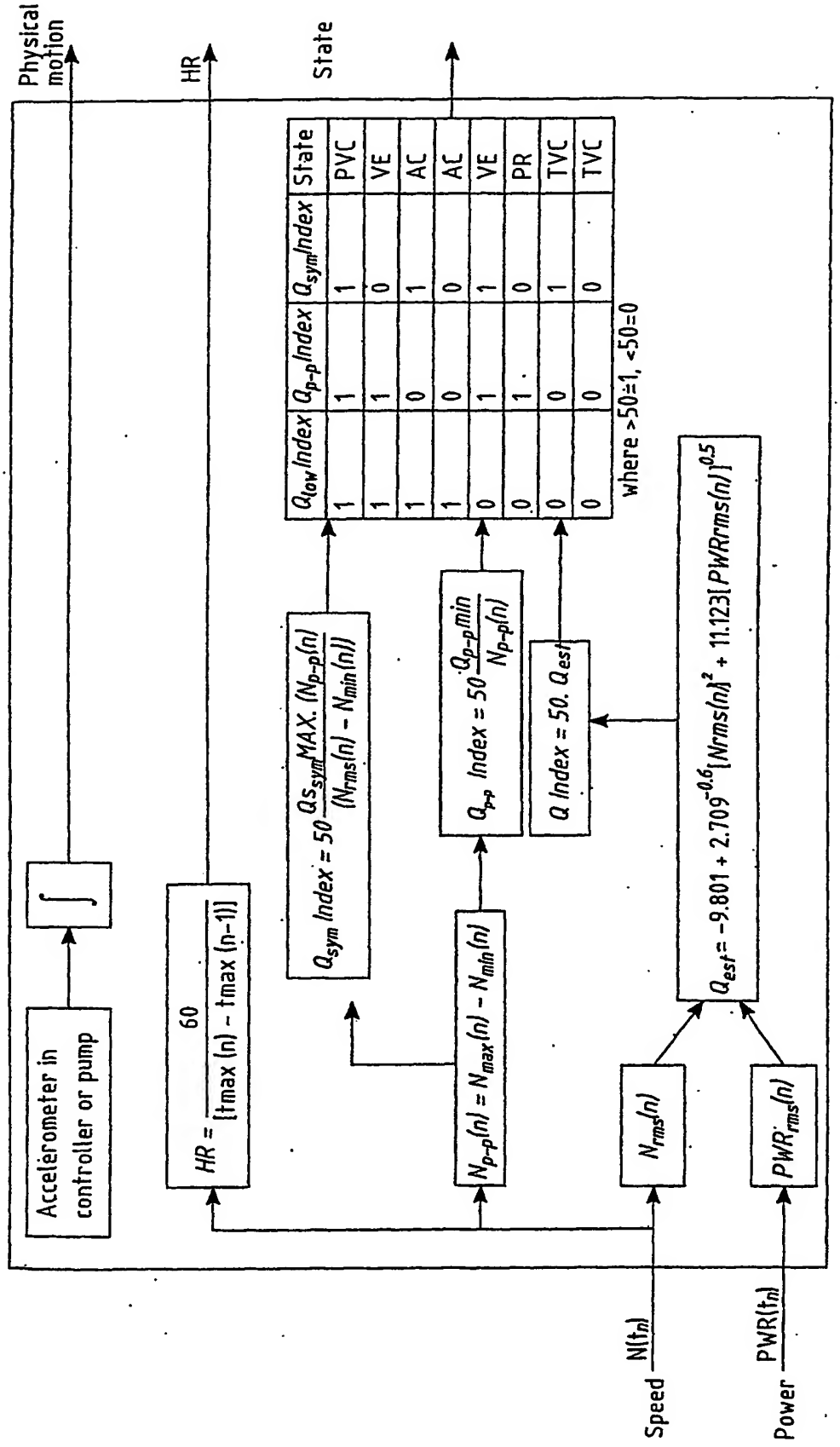
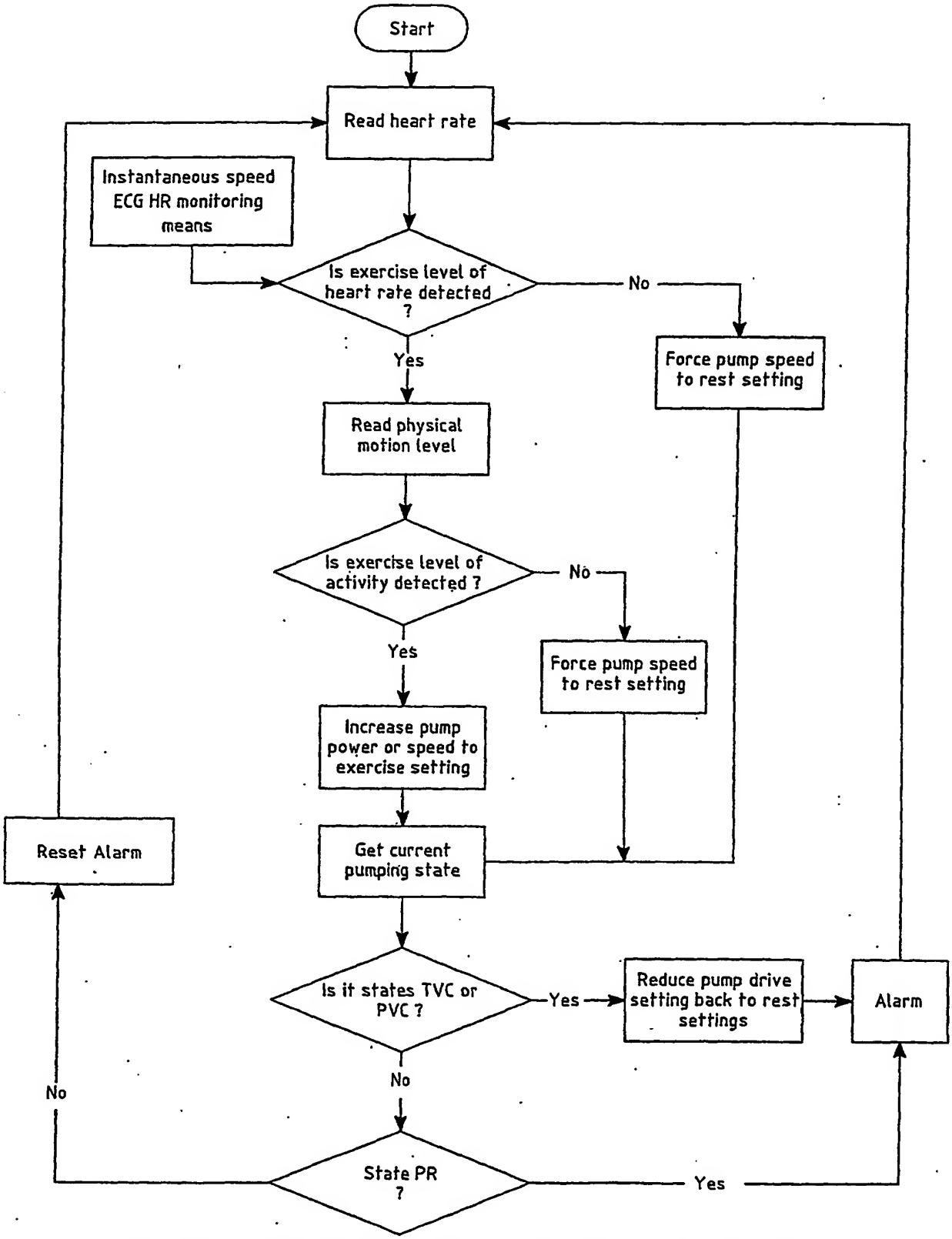

Pump Input
Power/speed drive
Increase or Decrease Pump Power
ALARM
Pumping State Indicator Total Ventricle Collapse: Partial Ventrical: Aortic Valve Closed; Ventricle Ejecting; and Pump Regurgitation.
Flow estimation
Pump Flow Mapping
Physical motion measuring means
Heart-rate monitoring means
Average Speed
Average Input Power
Averaging means
Averaging means
Instantaneous speed
Instantaneous Input Power

Fig. 5



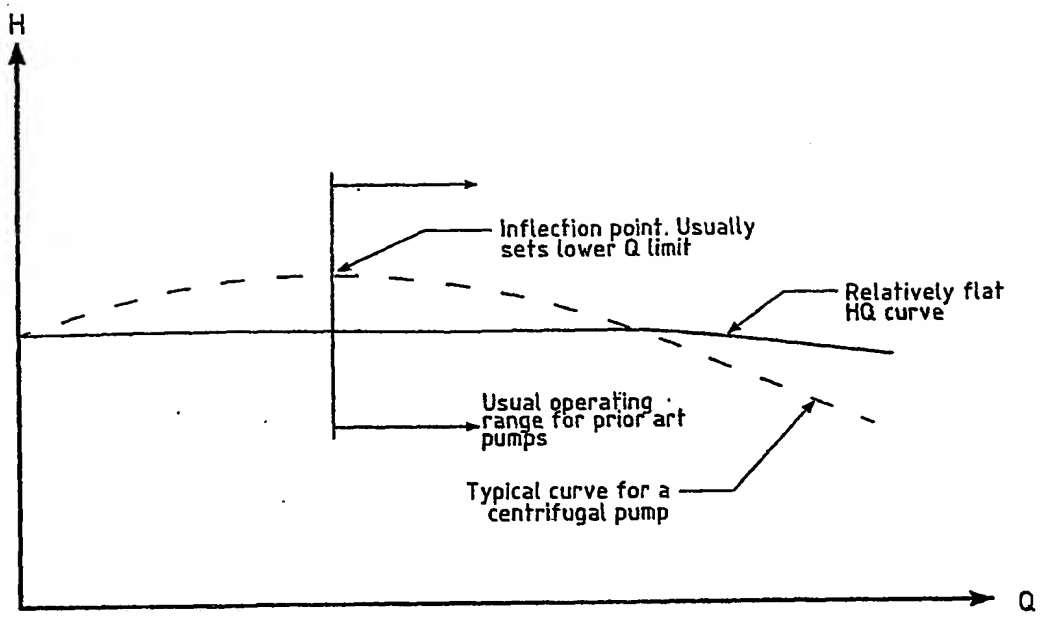
A block diagram of the Pumping state detection module. From instantaneous pump speed and power ($N(t)$, $PWR(t)$), rms speed and RMS power ($N_{rms}(n)$, $PWR_{rms}(n)$) were derived. From the RMS parameters, pump flow, $Q_{estRMS}(t)$) was derived. Pumping state indexes for TVC, PVC AC, VE, PR were generated from the RMS and instantaneous speed parameters given flow rate boundaries. Heart rate derived from $N(t)$ and physical motion intergrating the output of an accelerometer mounted in the controller or pump.

Fig. 6



Flow chart for determining pump drive set point change through the integration of the 3 methods of non-invasive detection (physical motion, HR and state detection) for exercise rate response control.

Fig. 7



HQ curves for the pump and a typical centrigugal pump which exhibits a peak in the HQ curve.

Fig. 8

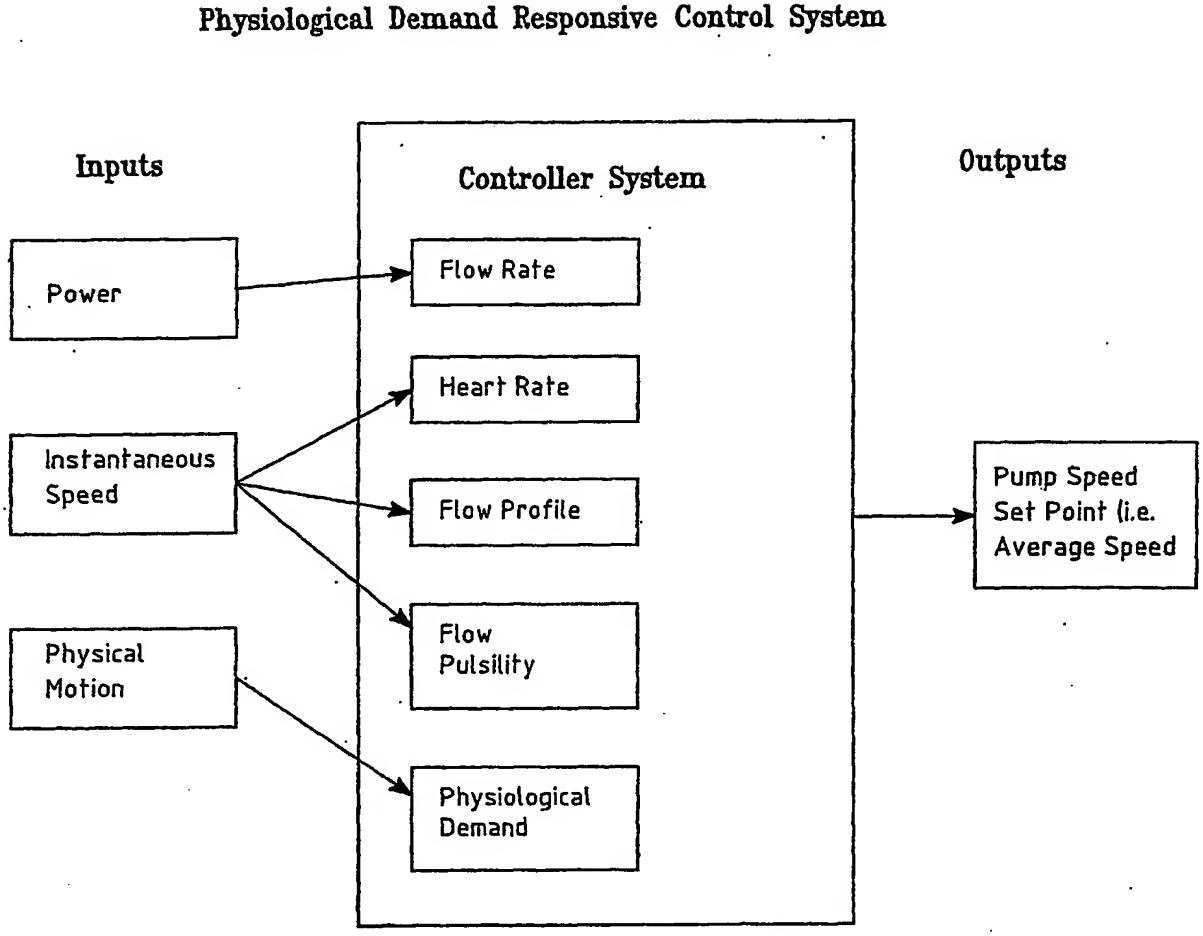

Physiological Demand Responsive Control System
Inputs
Controller System
Outputs
Power
Instantaneous Speed
Physical Motion
Flow Rate
Heart Rate
Flow Profile
Flow Pulsility
Physiological Demand
Pump Speed Set Point (i.e. Average Speed

Fig. 9